A TEXT-BOOK ON HELIOTROPISM.

Light and the Behaviour of Organisms. By Prof. S. O. Mast. Pp. xi+410. (New York: J. Wiley and Sons; London: Chapman and Hall, Ltd., 1911.)

THE question of the influence of light upon organisms must have appealed to the inquiring mind ever since a moth was seen to fly into a candle or a plant was observed to bend towards the sun. The closing of many flowers at night coinciding with the opening of others would have also been arresting movements to many unknown observers. But how subtle the influence of light may be has only comparatively recently been appreciated. The bending of plants towards the sun may readily be explicable on the ground of the importance of light in the preparation of the plant-food, but the hydroid zoophytes were discovered to possess the same property of bending towards the source of light, although they do not find thereby any known assistance to their maintenance. Larvæ of many diverse marine animals are also strongly attracted by light, and these, again, make no use of it so far as is known. Many animals, indeed, prefer rays of a particular region. As Lord Avebury showed years ago, the common Daphnia, if covered by a spectrum, aggregates under the green and yellow rays; ants, on the other hand, aggregate chiefly under the red and green rays, showing a special avoidance of violet and ultra-violet rays. Such varied and definite susceptibility seems quite unintelligible unless it is connected in some way with well-being, and no one has as yet shown any such correlation. The problems, then, of the meaning of the attraction or repulsion which light exerts are evidently very diverse, and the work of Mr. Mast is devoted to their analysis and consideration.

The first section contains an interesting historical summary of observations chiefly upon plants. Ray was apparently the first to suggest an explanation of the movements of plants, which he attributed to the flow of sap, being attracted to the problem by the sensitive mimosa then recently introduced from America. Early in the nineteenth century de Candolle reversed the daily periodic sleep-movements of leaves by exposing them to a new light rhythm—an interesting anticipation of F. Darwin's work. Many other points of interest are raised, including a discussion of the use of such terms as "tropism," originally the relation between the bending of a plant and the source of stimulation.

In part ii. the author sets out an account of his experiments on certain plants (Plumules of Indian corn and leaves of Tropæolum), and arrives at the conclusion that differences of light-intensity are responsible for the movements (observed by a special "light-grader"), but the method of regulating the movements is still a mystery. The section on the light-responses of unicellular plants and animals includes some original observations, as does that upon cœlenterates and various larval forms of higher animals. The general summary of this section is given on pp. 228–235, and includes a useful analysis of the work of many writers. The third part of the book is concerned with general considerations—the adaptive nature of light-responses, the phenomenon of aggregation in different intensities, and so on. This section and the last (which deals with reactions of animals to different wave-lengths) are very diffuse, and might well have been considerably shortened, as in many cases the discussions are not capable of leading to any definite solution; and if the excuse be offered that "behaviour" in its broadest sense was the subject of treatment, then surely the problem of colour-adaptation might have been mentioned. The points that emerge from this work are that there are many striking movements towards or away from the source of light which are quite unintelligible unless animal metabolism is favourably effected thereby, and we have no reason to suppose it is; and, secondly, that the way in which these orientations are effected is equally obscure. The book is written by a pupil of Jennings, who has done so much to analyse the behaviour of the lower organisms. It contains a very useful bibliography, and should prove helpful to that increasing number of experimental biologists and psychologists who are interested in the behaviour of organisms.

F. W. G.

PLEASANT PATHS OF NATURE.

The Airy Way. By George A. B. Dewar. Pp. vii+253. (London: Chatto and Windus, 1910.) Price 6*s*. net.

IN a delightfully breezy volume Mr. Dewar plays lightly on the word "airy" in its varying application, straying, by the way, into the rapid-running waters—the fishes' airy way. Following two most interesting chapters on flight and one on the watery way, the contents of the rest of the volume may be sufficiently indicated by the chapter headings dealing with the airy moor and links, the fritillaries' airy way, the airy lane and common, rooks in the airy way, and "my airiest downs"—a year's observations on the chalk. Field naturalists will be grateful to the author for his gift of conveying impressions in a few words—impressions which many may have felt, but could not perhaps express so aptly.

A few quotations from this pleasant book will serve to illustrate the pertinence of his remarks and the accuracy of his observations. Of the swift, a bird for which he has a great admiration, he says that it *is* flight, and is fitted with two scythes to cut and sweep through the air. Of the start of birds from the ground he writes:

"Hide behind a hedge or wall, and, when every pigeon beak is down, tap your stick on the ground. As you tap—whilst sound is still coming from the stone—every bird is in the air. You would as soon try to reckon the time between the hammer striking the cap and the discharge of the cartridge as reckon the time between the stick striking the stone and the discharge of the pigeon party."

And of the salmon:

"No man swims if a salmon swims. The keeping afloat, and the slow movements of a man in comparatively still water, should not be given the name we give to the swift, sure, glorious action of the salmon in the fury of storming streams. Does a man who

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sits in a flying machine which makes its way through the air 'fly'? If so, the swift and the merlin and eagle have an action for which we should find another name. One thing such acts have in common—progress. They have little else."

Mr. Dewar says truly that though no date in a calendar can end or begin winter, yet there are some natural events—small touches, but sure—that end one season and begin another. One of them is the nest—with the eggs—of the earliest song-thrush. "The nest may be set in a winter hedge, and a return of iron days and nights kill the work and prevent other thrushes starting on their nests for weeks to come. It does not signify. The first thrush nest found in March in the thorn or ivy, the clay dried, the eggs laid, ended winter." But he does not do the fly-catcher justice when he says it can squeak, and has besides a fretful monosyllable or so, and there is his music. It is true that the fly-catcher very rarely sings, and that many people have apparently never heard the song; but it does really sing occasionally for all that. How one wrong letter will alter the look of a sentence, and even puzzle the reader for a moment! We notice "swallow" written for "sallow" in one place, and "root" for "rook" in another.

TEXT-BOOKS OF PHYSICS.

(1) *Mechanics and Heat: a Text-book for Colleges and Technical Schools.* By W. S. Franklin and Barry Macnutt. Pp. x+409. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1910.) Price 7*s.* 6*d.*

(2) *A Text-book of Physics.* By H. E. Hurst and R. T. Lattey. Pp. x+638. (London: Constable and Co., Ltd., 1910.) Price 8*s.* 6*d.* net.

(1) WITHIN the last half-century much experience has been gained as to the methods which can be used most profitably in the teaching of science; nevertheless, there is still much diversity of opinion as to the best method to be used. Followers of the heuristic school maintain that a student should build up his knowledge of science by his own unaided exertions, the function of a teacher being to guide the student's mind insidiously toward the correct path. Has any teacher ever attempted to proceed severely on these lines? It may be doubted. So far as the teaching of physics is concerned, such an attempt would be so ridiculously futile that no one could have made it seriously. Ideas such as those connoted by the words "energy," "potential," "entropy," and a host of similar expressions could scarcely be derived by any student, even if he were of the type that might develop subsequently into a Kelvin or a Rayleigh. Quite apart, however, from the question of possibility, it may be argued that no student has received a satisfactory training unless he has learned to profit by the knowledge which has been accumulated by others. Dismissing, then, the claims of the heuristic system as enunciated by its most rigid adherents, the question arises, To what extent is a student necessarily dependent on personal observation, and to what extent is it profitable for him to imbibe ideas directly from his teacher? No general answer can be given to this question, since so much must depend on the personalities of both the student and the teacher; but if it be accepted that science is the study of real phenomena, it must follow that the practical work done by the student must be sufficiently extensive to give him a clear idea of the phenomena which he investigates. Not only the nature of the experiments, but the order in which they are performed, is of importance. Most of the difficulty experienced by students in becoming acquainted with the dynamical properties of solids and fluids is due to the practice of studying the laws of statics exhaustively before the laws of motion have been mastered; much of the time now spent in the experimental study of statics might be devoted with advantage to the performance of simple experiments designed to illustrate the laws of dynamics. In a systematic course of study an accurate and comprehensive knowledge of mechanical principles should be gained as early as possible, for most of the exact sciences cannot be mastered without such a knowledge.

Messrs. Franklin and Macnutt have advisedly devoted the first 269 pages of their text-book to the study of the mechanical properties of solids and fluids; such subjects as virtual work, the properties of rotating bodies (including the gyrostat), the analysis of the stresses called into play by straining an elastic substance, and the fundamental laws of hydrodynamics are dealt with in a simple but illuminating manner. A few errors may be noticed. The action of the Pitot tube cannot be deduced from the force exerted by a jet of liquid impinging normally on a plane. The velocity of stream, as measured by a Pitot tube, should be equal to $\sqrt{2gh}$, where h is the height at which the liquid stands in the tube, instead of $\sqrt{gh}$, as given on p. 260. The depression of the surface of the water escaping from the central outlet of a laboratory basin is not essentially due to rotation of the water; even when the water approaches the outlet radially its velocity must increase and its pressure must diminish. In general, however, the treatment of the subject is excellent, and the student is afforded an opportunity of becoming acquainted with many interesting phenomena connected with engineering practice, which are not generally mentioned in books devoted to the theory of mechanics.

The second part of the book is devoted to the study of heat. The first and second laws of thermodynamics are discussed fully, and the most interesting properties of solid liquids and gases are dealt with in passing. The graph given on p. 401 exhibits the rate of cooling of a teapot as compared with that of a Dewar's vacuum flask, and is interesting as showing that the rate at which the teapot loses heat is scarcely affected by radiation, being due almost entirely to convection and, to a small extent, to conduction. How many teachers, it may be wondered, have explained that a silver teapot loses heat more slowly than a porcelain one, on account of the high reflecting and consequent low radiating qualities of polished silver?

(2) Messrs. Hurst and Lattey have written this book for students preparing for the Preliminary examina-

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